STRATIGRAPHIC ASSESSMENT OF SAND RESOURCES OFFSHORE HOLLY AND PEVETO BEACHES, LOUISIANA

Karen E. Ramsey
Shea Penland

Louisiana Geological Survey
Center for Coastal, Energy, and Environmental Resources
Box G, University Station
Baton Rouge, Louisiana 70893
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ABSTRACT

Coastal communities and resorts of Johnson's Bayou, Ocean View Beach, Constance Beach, Peveto Beach, Holly Beach, and Hackberry Beach as well as Highway 82 are threatened by increasing beach erosion and storm-impact vulnerability. Several attempts have been made to armor the shoreline in this area; however, coastal protection experience in Louisiana and other U.S. coastal states indicates shoreline restoration projects are more effective and environmentally compatible than armoring a shoreline with a seawall. The primary objective of this study is to determine the textural characteristics of parent material in the Holly Beach and Constance Beach region to identify compatible offshore sources that will serve as borrow material for replenishment of these eroding coastal shorelines.

Over 500 line-km of shallow, seismic reflection data offshore the chenier plain have been obtained collectively by the Louisiana Geological Survey, Minerals Management Service, and U.S. Geological Survey. Onshore sand characteristics were obtained from 15, grab-sample transects from low-tide, mid-tide, high-tide, and dune regions at 400-m intervals. Beach sands are generally very well sorted and very fine, with fine-grained dunes. Westward, towards Highway 82, grain-size fractions for roughly a half mile on either side of the breakwater revetment system tend to remain constant from the low-water to dune line (3.0–3.1 ϕ). Sand tends to be very well sorted to well sorted away from the maintained beach front area. Surficial sand samples near Constance and Ocean View beaches tend to have a more natural trend. Samples taken from the low-water line indicate a well-sorted, fine-grained (2.3 ϕ) material, fining upward (2.4–2.6 ϕ) towards the high-water line. Farther onshore and into the dune region, sand coarsens slightly into a well-sorted, fine-sand fraction (2.3 ϕ).

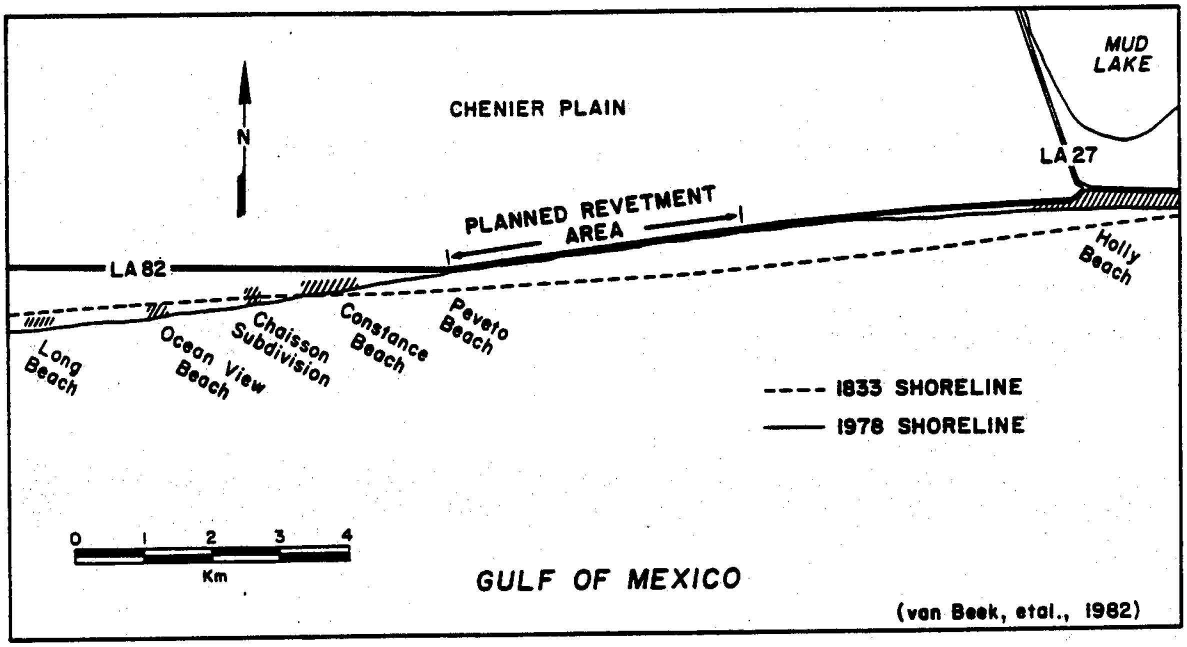
Offshore sand thickness averages 6 m, with 6 m of silty clay and clay overburden from buried fluvial channels and ancient sand ridges. Suter and Penland (1985) identified two potential borrow sites 5 to 8 km offshore Holly and Peveto beaches. The first target site with the best potential for borrow material is a 31-km^2 area derived from a Pleistocene fluvial channel system cut into the continental shelf. Water depth in this region ranges from 4 to 7 m. Seismic interpretations indicate as much as 175,000,000 m^3 of very poorly sorted sand ranging from 2.4 to 8.8 m thick, with 1.6 to 5.2 m of unconsolidated clay and silty clay overburden. The second target site covers approximately 60 km^2 of thinner fluvial deltaic and reworked shoreline deposits. It also contains slightly finer sand and as much as 90,000,000 m^3 of sand with coarse silt and 1.4 m of overburden.

INTRODUCTION

Mudflats, natural and modified sandy beaches, and transgressive beach ridges constitute the chenier plain of southwestern Louisiana. Today, coastal communities and resorts of Johnson's Bayou, Ocean View Beach, Constance Beach, Peveto Beach, Holly Beach, and Hackberry Beach are threatened by increasing beach erosion and storm-impact vulnerability (figure 1). State Highway 82 is faced with destruction, thereby cutting off this section of coast from direct access and threatening public safety.

Previous studies by Morgan and Larimore (1958) indicate that the shoreline from Holly Beach to Constance Beach was fairly stable until 1954. These observations were based on ground and aerial surveys between 1812 and 1954. Adams et al. (1978) expanded this study to 1969 using aerial photography and photo mosaics. They determined that an increase in the rate of shoreline retreat occurred after 1954 and showed that the Ocean View shoreline remained stable, with a zero net rate of change. However, the area from Constance Beach to Peveto Beach had average retreat rates of 3.9 m/yr and 6.0 m/yr just west of Holly Beach. Retreat rates at Holly Beach ranged from 2.1 to 3.9 m/yr.

Morgan and Morgan (1983) also updated Morgan and Larimore (1958) to include the 1969 data set (figure 2). They concluded that for the period 1932 to 1954, the jetties at the mouth of the Sabine River trapped littoral sediment to cause land accretion of about 147 acres west of Holly and Constance beaches. However, during the ensuing years to 1969, one hundred seventy acres were lost in the same area to result in little to no change over the entire period of study. This sector of the coast line indicated rapid erosion following Hurricanes Audrey in 1957 and Carla in 1961. Rates in this region were 8 to 9 acres per year from 1932 to 1969. In 1971, the U.S. Army Corps of Engineers (USACE) presented results from a littoral transport study for the chenier plain that indicated an estimated 62,000 to 100,000 yd^3 of sediment are transported in the littoral zone. However, very little if any of the sediment reaches the shoreline between Peveto Beach and the Calcasieu River. Based on retreat rates of 1.07 m/yr, the USACE (1971) estimated this area was losing between 23,703 and 35,172 m^3 of sand per year. The Louisiana Geological Survey (LGS) has



(van Beek, etal., 1982)

Figure 1. The study area extends from Holly Beach west to Ocean View Beach within the chenier plain.

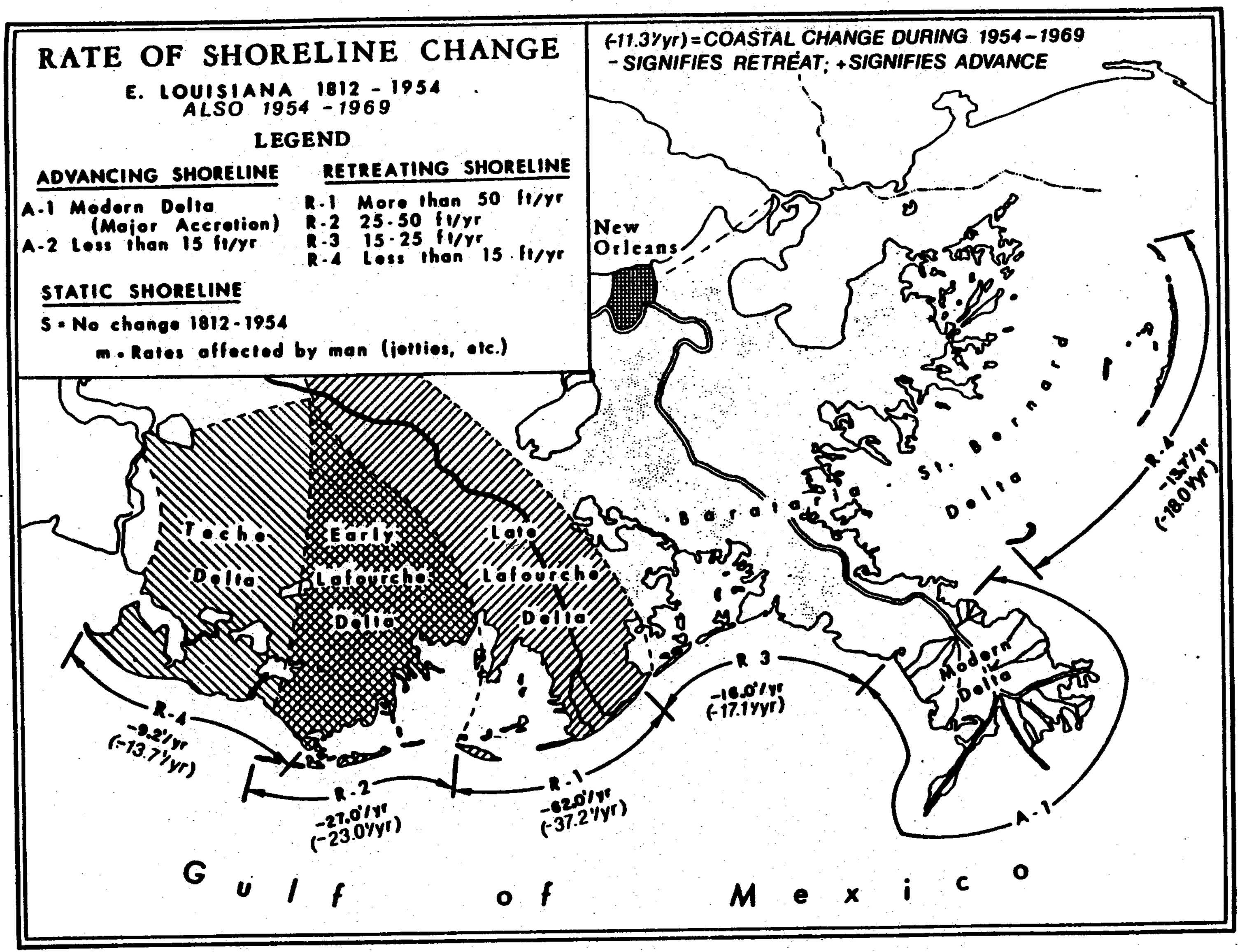


Figure 2. Shoreline change in western Louisiana (Morgan and Morgan 1983).

monitored this area since 1983. Between 1985 and 1988 shoreline retreat rates averaged 1.8 m/yr, with an average change in volume of 1.2 m^3/m-yr (Nakashima 1988).

The Peveto Beach shoreline has deteriorated to the point that the shoreline has encroached on Highway 82, and the beach is no longer existent. Highway 82 has been relocated several times because it is the only thoroughfare for residence in these communities, and it is economically important to pipeline companies. Several attempts have been made to armor the shoreline in this area. A 9-km-long concrete and rock seawall was erected in 1969 but has had to be reconstructed several times because of hurricane and storm damage. The coastal armoring consists of rock rip rap, concrete gobi blocks, and different types of protective textiles. In 1970, construction of six breakwaters composed of timber piles and old tires was started in front of the seawall. Construction was not completed until December 1985. LGS beach-monitoring surveys indicated that from 1985 to 1988 shoreline retreat rates downdrift of this seawall increased to about 3.3 m/yr (Nakashima 1988). As a result, these areas are becoming increasingly vulnerable to storm impacts and coastal erosion.

Maintenance of the existing seawall and breakwater system is costly, labor intense, and typically focused on crisis management. Armoring the shoreline has produced an erosional shadow zone that impacts communities downdrift. To compensate for this effect, an extended breakwater system has been established from behind the old system to Constance Beach, with plans to extend this system in the near future to the point of shoreline accretion. Accompanying placement of breakwaters is a plan for beach replenishment at strategic sites. Appropriate long-term management of this coastal region lies in beach and shoreline restoration using sediment and vegetation on a regularly scheduled maintenance plan.

Coastal protection experience in other U.S. coastal states and here in Louisiana indicates shoreline restoration projects are more effective and environmentally compatible than armoring a shoreline. The primary objective of this study is to determine the textural characteristics of parent material in the Holly Beach and Constance Beach region to identify compatible offshore sources that will serve as borrow material for replenishment of these eroding coastal shorelines.

Offshore the chenier plain, the continental shelf reaches a maximum width of 240 km south of Cameron, Louisiana. An inventory of existing geophysical data supplemented by high-resolution, shallow seismic profiles and vibracores indicate a wide range of sand resources on the continental shelf. Three types of aggregate sands recognized offshore the chenier plain are undifferentiated sand shoals, Late Wisconsinan fluvial channels, and barrier island platforms (Penland et al. 1988). This report is a consolidation of information regarding sand resources, with emphasis on the potential for beach replenishment of Holly and Constance beaches in western Louisiana.

REGIONAL GEOLOGY

The chenier plain is a series of alternating prograding mudflats separated by reworked sand and shell ridges that extends 200 km from Sabine Pass, Texas, to Southwest Point, Louisiana, and ranges in width from 20 to 30 km (figure 3). Formation of the chenier plain began during the Holocene when the Mississippi River shifted towards the southwest to allow sediment deposition from main distributaries, creating shallow-water mudflats along the shoreline. As the river shifted eastward, sediment supply through the distributaries was diminished and a reworking of the shoreline occurred to produce chenier ridges of sand and shell. Recurrence of these processes has produced the alternating chenier ridge and mudflats of southwestern Louisiana. Elevations of these ridges vary in the chenier plain from 2 m to 6 m (Gould and McFarlan 1959). Wells and Roberts (1981), Wells and Kemp (1981), Wells (1986), and Kemp (1986) have shown that mudflat development has occurred since the development of the Atchafalaya delta and can be linked to the passage of cold fronts and hurricanes. The newly formed mudflats represent the eastern chenier plain shoreline located west of Freshwater Bayou and in the Cameron-Calcasieu area. Natural and modified sandy shorelines can be found west of the prograding mudflats from Johnson's Bayou to Calcasieu Pass. These modern day shorelines represent the most recent sand and shell ridge formation along the chenier plain (figure 4).

Offshore the chenier plain are ancient fluvial systems and Holocene deltaic deposits associated with the Maringouin and Lafourche delta complexes. Based on interpretations from high-resolution seismic reflection

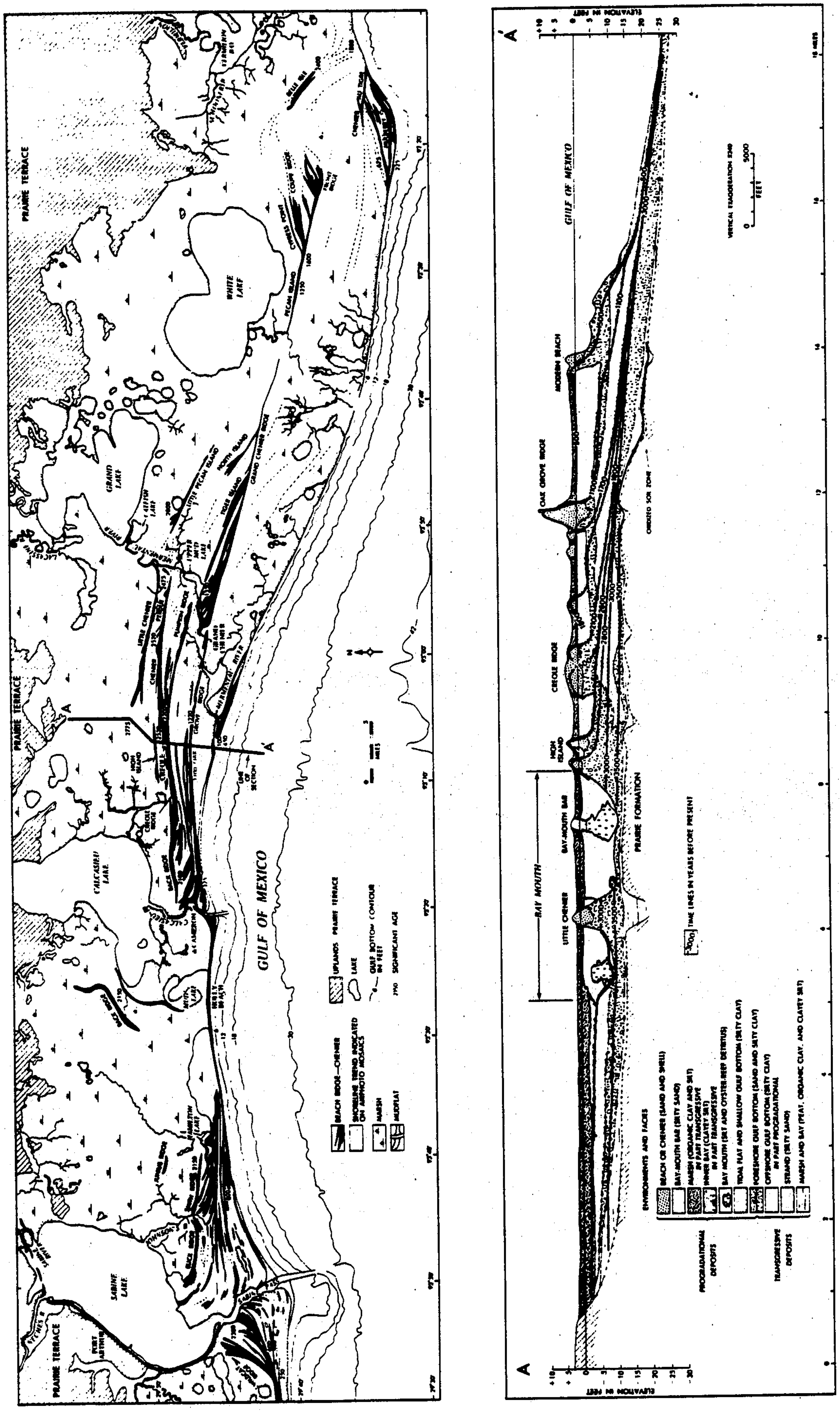


Figure 3. Sand and shell ridges of the chenier plain (Penland and Suter 1989).

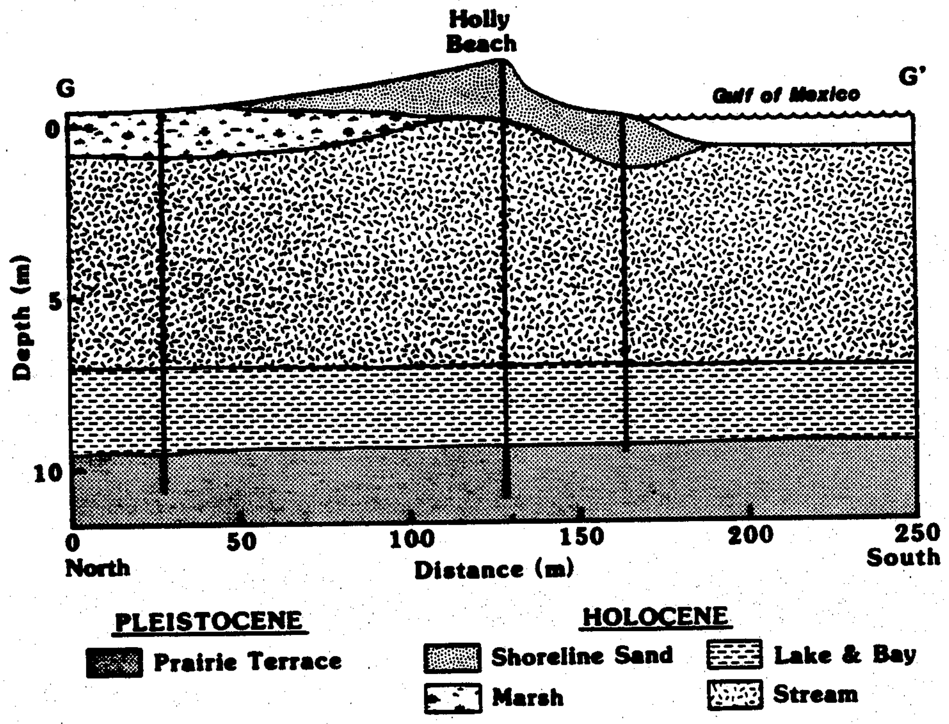


Figure 4. Cross section of Holly Beach showing beach ridge with underlying stream deposit sediment (Penland and Suter 1989).

data, Suter (1986) describes the ancient fluvial channel deposits as the largest coarse-grained deposits on the western shelf, reaching up to 60 m thick. This sediment was deposited along the shelf edge during maximum glaciation when sea level withdrew to or near the shelf margin. Fisk (1944) explains that as continental glaciers melted, rising sea level submerged these fluvial systems to form estuaries that eventually were filled with sediment as the sea transgressed. Holocene deposits are described as fine-grained sediment deposited during the late Wisconsinan and Holocene transgressions. These occur as channel-fill deposits, undifferentiated sand shoals, and barrier island platforms (Penland et al. 1988). They thicken towards the modern delta and reach a maximum thickness of 15 m (figure 5; Suter 1986).

METHODOLOGY

Data Base

Offshore sand deposits on the continental shelf are mapped using high-resolution seismic reflection profile data and vibracores (figure 6). LGS and the U.S. Geological Survey (USGS) have cooperatively collected over 500 line-km of shallow, seismic reflection data at a 1-km^2 grid spacing using an ORE Geopulse seismic system. The USGS and U.S. Minerals Management Service (MMS) have cooperatively collected a southwest Louisiana shelf data set consisting of 20,000 line-km of shallow, seismic reflection data at a 5.5-km^2 grid spacing using a Minisparker and 3.5-kHz sub-bottom profiler. Onshore sand size characteristics were obtained from grab samples collected along Holly, Peveto, Constance, and Ocean View beaches (appendix A). Twenty-two transects were selected for sample collection from low-tide, mid-tide, high-tide, and dune areas at 400-m intervals (figure 7). In most cases, the dune areas showed very little relief or were non-existent. Samples in these areas were taken at the vegetation line where the relief of the beach changed. In areas where the shoreline abuts the highway (e.g., Constance Beach), no dune sample was taken. Grab sample transects were integrated with an existing data base of beach profile transects to determine target areas for beach nourishment using offshore sand resources.

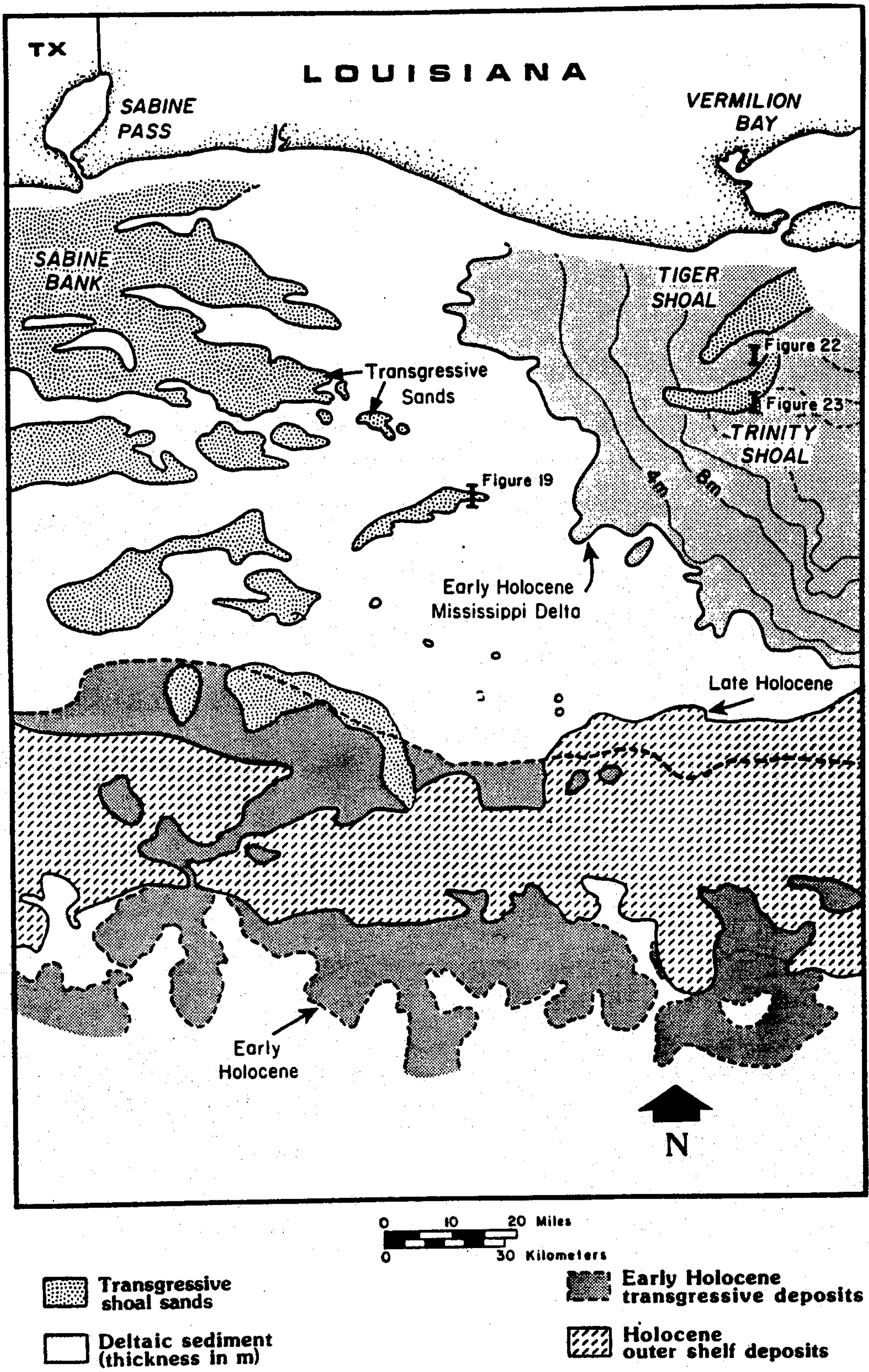


Figure 5. Location of reworked sand ridges in southwest Louisiana (Suter 1986).

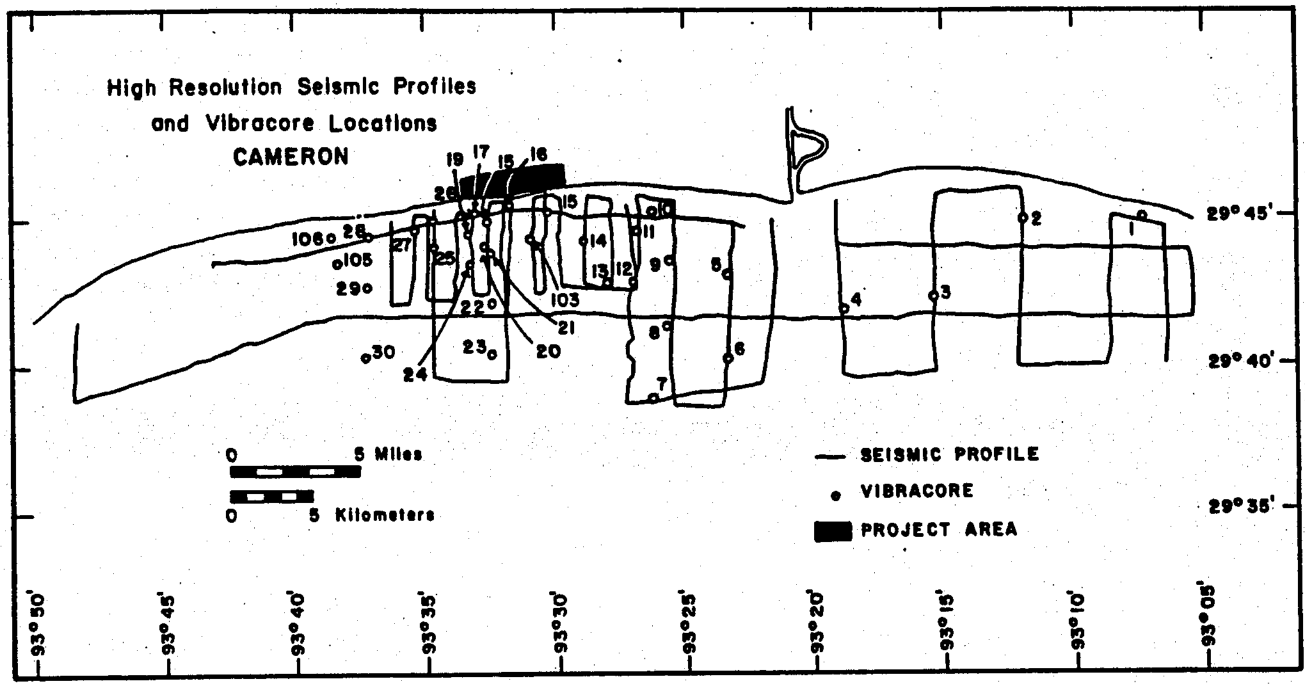


Figure 6. High-resolution seismic survey profiles and vibracore location data base from the Louisiana Geological Survey.

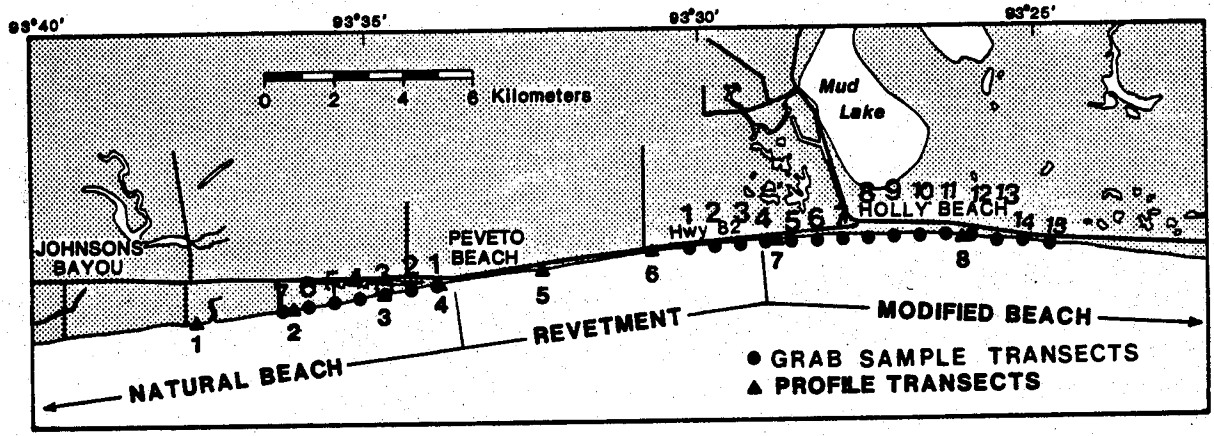


Figure 7. Location of sediment sample transects between Ocean View and Holly Beach. Grain-size and sorting statistics for grab samples are located in appendix A.

Seismic Surveys

Seismic reflection profiles were used to select vibracore locations for ground truthing acoustic reflectors to determine geologic framework and sand resource availability. Seismic survey trackline grids were designed according to several variables, including the ship time available for the cruise, the range and fuel capacity of the research vessel, the locations of coastal ports, knowledge of coastal geomorphology and historical shoreline change, and the degree of detail required for the task. For the study area, grids were established in a shore-parallel and shore-perpendicular pattern to provide continuous coverage of potential sand resource targets in state and federal waters. For the purpose of regional mapping of continental shelf deposits and determination of possible hard mineral resources, some coarsely spaced lines were extended farther out onto the shelf.

Datasonics or ORE 3.5-kHz sub-bottom profilers are used as high-frequency tools in these surveys. An ORE Geopulse system was used to provide greater penetration. Vertical resolutions of the two tools are about 0.5 m and 1.5 m, respectively. Penetration averaged about 10 m for the 3.5-kHz device and reached 50 m or more for the Geopulse. Data quality was quite variable and usually poorest in shallow waters of the nearshore zone. The return signals are displayed at 1/4-second sweeps or split traced on an EPC 3200 recorder at sweep rates of 1/8 second for each channel to result in an effective display of 1/4 second for the record. Filter settings and power outputs were varied depending on the survey area. Figure 8 is an example of seismic data showing Wisconsinan fluvial channels of the southwestern Louisiana continental shelf.

Navigation was accomplished using a Northstar 600 LORAN-C receiver corrected with a Morrow XYP-2000 real-time LORAN-C plotter. These data were recorded in real time aboard ship and stored on magnetic tape. Through comparison with points of known locations on charts, the LORAN-C was estimated accurate to within 40 m. Using an INTERGRAPH workstation, tracklines for various cruises were digitized, put into a uniform format, and plotted at a scale of 1:80,000. Preliminary maps of acoustic targets considered to be most prospective for sand or aggregate resources were drawn on the trackline map based on initial interpretations of the seismic profiles. LORAN-C is a readily available, inexpensive electronic navigation technique.

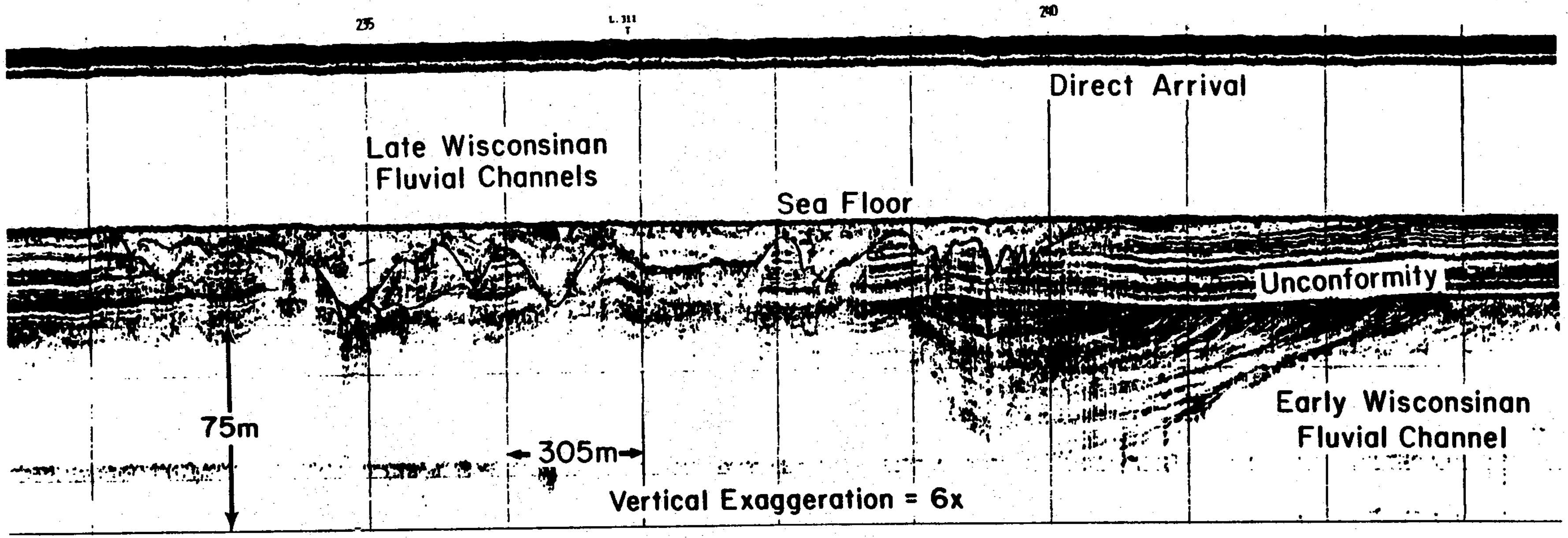


Figure 8. Representative seismic section showing late Wisconsinan fluvial channels offshore southwestern Louisiana.

Vibracore Analysis

Vibracores were split lengthwise using a circular saw equipped with an 18-cm carbide-tipped steel blade and aluminum guide designed so the saw will follow a straight path over the length of the core pipe. A steel wire is pulled lengthwise through the core pipe along the saw cut, dividing the core into equal halves. The first half is trimmed with an osmotic knife, physically described, wrapped in plastic, and archived for future reference. The other half of the core is sampled for grain size, radiocarbon-dating material, x-ray radiograph slabs, and epoxy relief peels. Each vibracore is sampled for sediment grain-size analysis at an interval averaging 1 to 2 m, except when sand bodies over 1 m thick are encountered. Here, the sampling interval for the sand bodies averages 0.5 m or less. Analysis of sedimentary structures and facies within the core is accomplished through visual examination of the core, epoxy relief peels, and x-ray radiography. The information from cores is recorded on a standardized description sheet, which accommodates information concerning sedimentary structures, textural characteristics, bedding thickness, particle size, and additional analyses performed on the core.

Surficial Sediment Sampling

A 100-gm grab sample was collected along transect lines from Holly Beach to Ocean View Beach. Samples were placed in a cloth sample bag to allow for any water drainage. These samples were then transported to the LGS sediment laboratory for textural analysis. Subsamples were obtained from each grab sample, and a textural analysis was performed to assess native grain size characteristics of the beach.

Textural Analysis

Subsamples obtained from each grab sample and vibracore were placed in a glass beaker and dried in a Fisher Isotemp oven at an average temperature of 65°C. Higher temperatures were avoided to prevent any clay-sized sediment from baking. Subsamples are normally dried overnight (16 hours) and allowed to attain equilibrium the next morning by cooling at room temperature for at least one hour before weighing. Sediment samples were then completely disaggregated using a mortar and pestle prior to sieving. Cast acrylic sieves with mesh sized ranging from 1.25 ϕ (medium sand) to 4.00 ϕ (very fine sand) are assembled at a 0.25 ϕ interval. Sediment finer than 4.00 ϕ was considered the fine-size fraction (silt and clay) of the sample. The sieves were systematically cleaned before each sample was processed, then stacked with the coarsest sieve on top and the finest on the bottom. The sediment sample was added to the top, and the entire nest of sieves was placed in a sonic sifting unit, which vibrates the subsample for approximately two minutes. Upon completion, each sieve was emptied onto a large sheet of paper and transferred to a labeled, pre-weighed beaker. A Sartorius selectronic digital balance was used to weigh all samples to an accuracy of 0.001 g. The individual weights per phi interval were then entered into a sediment analysis program to calculate grain-size statistics. This program calculates Folk, Inman, and moment measure statistics (mean, sorting, skewness, and kurtosis); textural descriptions; phi percentiles; weight values; weight percents; and cumulative percentages. Grain size in this report is indicated with phi value (see table 1 for conversion to millimeters). Cumulative frequency curves are produced from the initial data using a commercial spreadsheet computer program.

RESULTS AND DISCUSSION

Native Beach Sands

Surficial grab samples taken along 15 transects from Ocean View Beach to Holly Beach indicate that the beach sediment is generally fine to very fine and well to very well sorted (figure 7, table 2). Because Holly Beach is a recreational coastline with summer camps, the beach has been modified and maintained frequently by mechanical graders. Consequently, textural characteristics from low water to the dune are basically uniform. Beach sands are generally very well sorted, very fine sand (2.8 to 3.1ϕ), with fine-grained dunes (2.7 to 2.9 ϕ). Moving westward towards Highway 82, grain-size fractions for roughly a half mile on either side of the breakwater revetment system tend to remain constant from low water to dune line (3.0 to 3.1 ϕ). Sand tends to be very well sorted to well sorted away from the maintained beach front area. Westward towards Constance and Ocean View beaches, surficial sand samples tend to have a more natural trend.

Table 1. Krumbein's grain size for sediment

U.S. Standard Sieve Mesh #	Millimeters (1 Kilometer)	Phi (o)	Wentworth Size Class
10	2.00	-1.0	Very coarse sand
12	1.68	-0.75	
14	1.41	-0.5	
16	1.19	-0.25	
18	1.00	0.0	Coarse sand
20	0.84	0.25	
25	0.71	0.5	
30	0.59	0.75	
35	0.50	1.0	Medium sand
40	0.42	1.25	
45	0.35	1.5	
50	0.30	1.75	
60	0.25	2.0	Fine sand
70	0.210	2.25	
80	0.177	2.5	
100	0.149	2.75	
120	0.125	3.0	Very fine sand
140	0.105	3.25	
170	0.088	3.5	
200	0.074	3.75	
230	0.0625	4.0	Coarse silt
270	0.053	4.25	
325	0.044	4.5	
	0.037	4.75	
Analyzed by Pippette or Hydrometer	0.031	5.0	Medium silt
	0.0156	6.0	Fine silt
	0.0078	7.0	Very fine silt
	0.0039	8.0	Clay
	0.0020	9.0	

Table 2. Surficial sediment grain-size statistics for Ocean View to Holly Beach, Louisiana.

Mean Grain Size

Ocean View		Constance Beach		Peveto - Beach (Highway 82)										Holly Beach							
Developed	Natural	Developed	Natural	Natural			Natural - Modified Beach							Developed				Modified Beach			
2.3	2.3	–	–	–	–		–	2.8	2.7	2.5	2.7	2.4	3.0	–	2.9	2.9	3.0	2.8	2.8	2.7	–
2.7	2.7	2.5	–	2.6	2.6		2.8	2.8	3.0	3.1	3.1	3.0	3.1	3.0	3.0	2.8	2.9	3.0	2.9	–	2.8
2.4	2.6	2.2	2.4	2.6	2.6		2.7	2.7	3.1	3.0	2.9	3.1	2.1	3.1	3.0	2.9	2.8	2.9	3.0	2.8	–
2.3	2.5	2.3	–	–	–		–	–	3.2	3.1	3.1	3.1	3.1	3.1	3.0	2.8	2.9	3.0	2.9	2.8	–

Sorting

Ocean View		Constance Beach		Peveto - Beach (Highway 82)										Holly Beach							
Developed	Natural	Developed	Natural	Natural			Natural - Modified Beach							Developed				Modified Beach			
W	W	–	–	–	–		–	W	W	W	W	W	VW	–	VW	VW	VW	W	VW	W	–
W	W	W	–	W	W		W	W	VW	VW	VW	VW	VW	VW	VW	VW	VW	VW	W	–	VW
W	W	W	W	W	W		W	W	VW	W	W	VW	VW	VW	VW	VW	W	W	W	W	–
W	W	W	–	–	–		–	–	VW	VW	VW	VW	VW	VW	W	W	MW	MW	VW	MW	–

Skewness

Ocean View		Constance Beach		Peveto - Beach (Highway 82)										Holly Beach							
Developed	Natural	Developed	Natural	Natural			Natural - Modified Beach							Developed				Modified Beach			
NS	NS	–	–	–	–		–	C	NS	NS	NS	C	C	–	C	NS	C	C	C	NS	–
C	C	NS	–	C	C		C	C	C	C	NS	C	C	C	C	C	C	C	NS	–	NS
F	NS	F	NS	NS	NS		C	C	NS	C	C	C	C	C	C	NS	C	C	C	C	–
F	NS	NS	–	–	–		–	–	NS	C	C	C	C	C	C	C	C	C	C	C	–

W - well sorted; VW - very well sorted; MW - moderately well sorted; NS - nearly symmetrical; C - coarsely skewed; F - finely skewed

Samples taken from the low-water line indicate a well-sorted, fine-grained material (2.3 ϕ), fining upward towards the high-water line (2.4 to 2.6 ϕ). Further onshore and into the dune region, sand coarsens slightly into a well-sorted, fine-sand fraction (2.3 ϕ).

Offshore Resources

Offshore sand resources are mainly composed of flood plain channel-fill deposits and reworked sand ridges. Vibracore and deep industry borings reveal pockets of light gray to gray, poorly to moderately sorted, fine sand with clay seams (appendix B). These deposits are described as part of an ancient fluvial system and not an individual channel. Therefore, sand thickness and amount of overburden vary throughout the offshore region, and resource data tend to be an overestimate of actual borrow material. The average thickness of the sand fraction is 6 m, with 6 m of silty clay and clay overburden (figure 9).

Suter and Penland (1985) identified two potential borrow sites 3 to 5 miles offshore of Holly and Peveto beaches (figure 10). The first target site with the best potential for borrow material is a 31-km^2 area derived from a Pleistocene fluvial channel system cut into the continental shelf. Water depth in this region ranges from 4 to 7 m. Textural logs and data from nine vibracores taken at this site indicate that the borrow material consists of 54% poorly sorted sand, ranging from 2.4 to 8.8 m thick, and a 1.6-m to 5.2-m overburden of fine, unconsolidated clay and silty clay. Generally, this deposit fines upward where most of the sand does not ideally match the characteristics of the native beach sands. Mean grain size of these deposits is 4.07 ϕ. Seismic interpretations by Suter and Penland (1985) show that these channels can reach over 18 m thick, and as much as 175,000,000 m^3 of sand and coarse silt are contained within the system. Overburden sediment is interpreted as channel fill, estuarine, and open-shelf deposits.

The second target site covers an area of approximately 60 km^2 and interpreted as thinner fluvial, deltaic, and shoreline deposits reworked during the Holocene transgression. Water depth in this region ranges from 4 to 10 m. These deposits are overlain by fine-grain, open-shelf deposits. Textural logs and grain-size statistics from 12 vibracores indicate that the sand fraction is roughly 1.5 m thick and composed of 48% sand

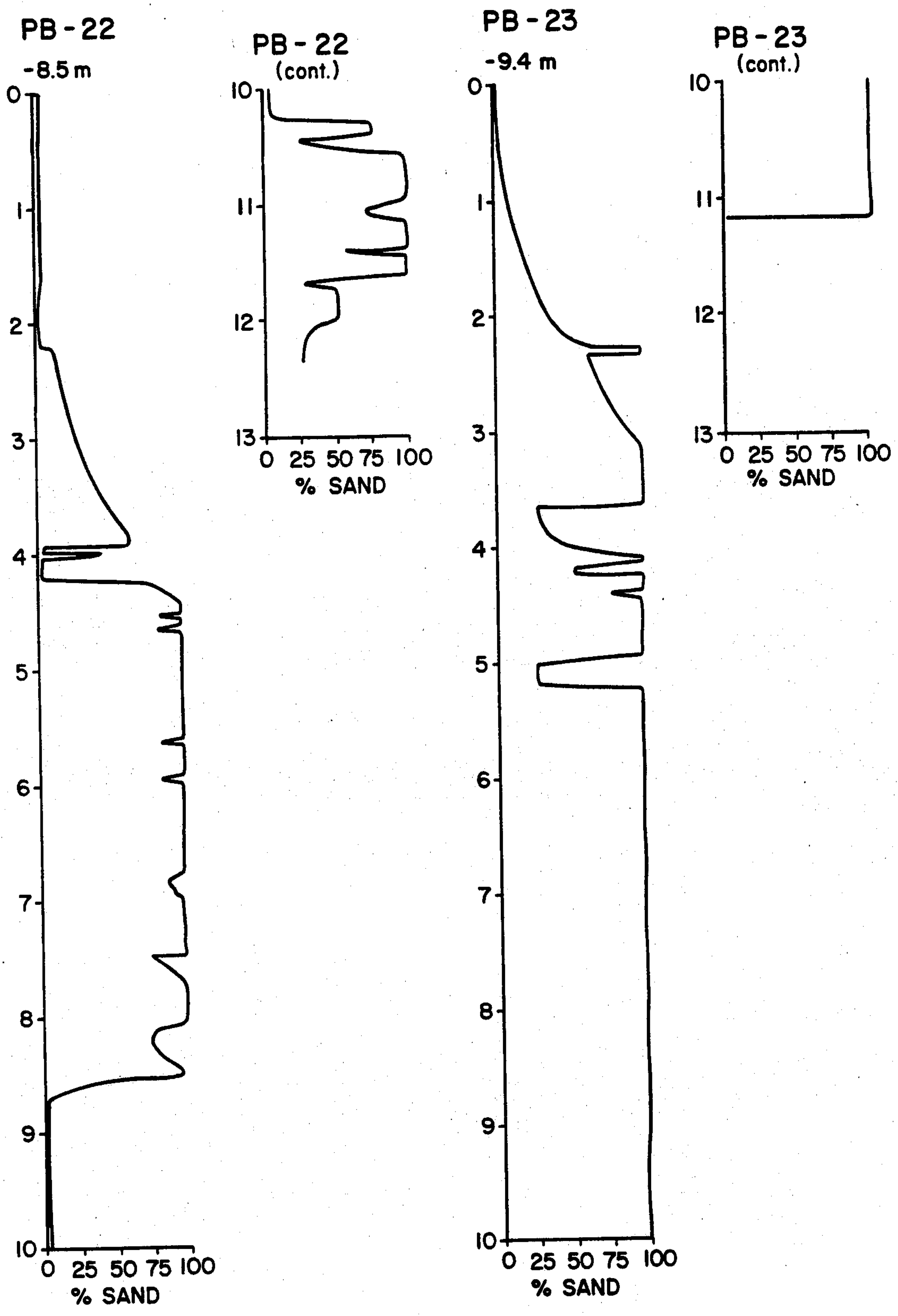


Figure 9. Textural logs from offshore vibracores taken along the chenier plain.

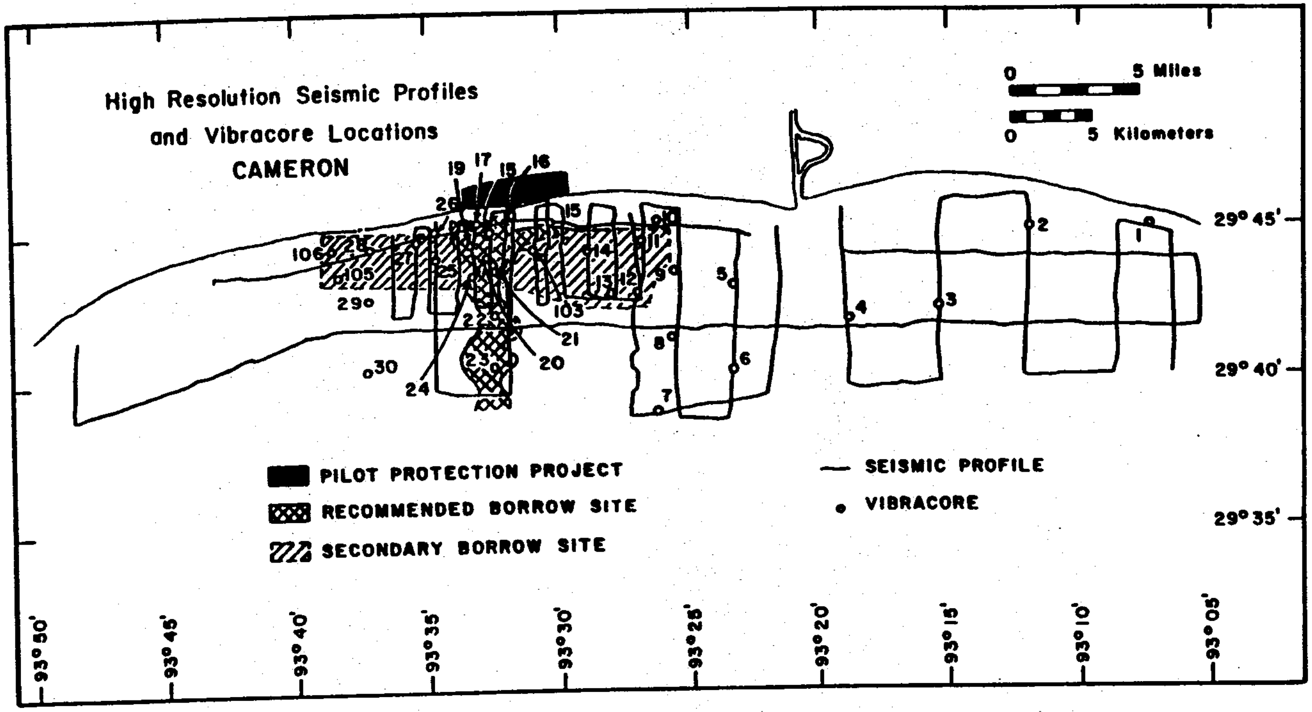


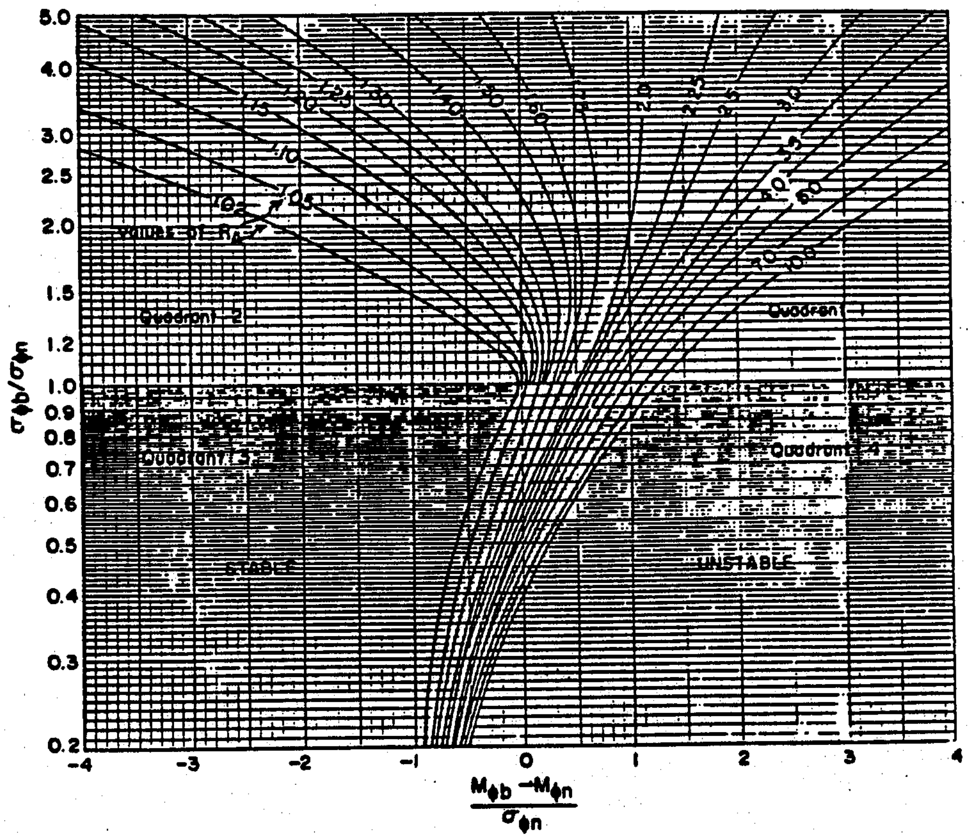
Figure 10. Two recommended borrow sites for beach replenishment of Holly Beach and Highway 82 shoreline (Suter and Penland 1985).

with 1.4 m of overburden. The sediment in target area II is slightly finer than in target area I, with a phi value of 4.27. Seismic and vibracore interpretations indicate this targeted region contains as much as 90,000,000 m^3 of sand and coarse silt.

Compatibility of Sediment

Primary concerns in designing a beach replenishment project are the amount of sand required from a borrow site to restore the beach, the compatibility of the material relative to the natural beach, and the behavior of the material after relocation. As with native beach material, borrow material will undergo the same sorting processes that occur on a natural beach. Finer material will be redistributed offshore and lost to the system to create a coarser grained residual on the beach. Therefore, to evaluate the stability of beach design relative to the native beach, an overfill factor (R_a) must be calculated. Krumbein and James (1965) and James (1974) provide a method for estimating stability of beach fill using mean grain size and sorting characteristics (figure 11). This overfill factor is the estimated number of cubic meters of fill material required to produce 1 m^3 of beach material. The standard deviation from the overfill calculation is a measure of the sorting. A replenishment factor, R_j, determines how often replenishment of sediment will be needed if the borrow material exhibits a different texture from the native beach material. Beach-fill ratios have been calculated for beach replenishment of Holly, Peveto, Constance, and Ocean View beaches using sediment from both potential borrow sites. Sediment from target area I is slightly finer than sediment located at target area II; however, target area I runs parallel to the shore, while target area II sands are perpendicular and could require dredging in slightly deeper water. Overfill factors to replenish each of the coastal beach sites are listed in table 3. Holly Beach has the best potential as a replenishment site for sands located in the nearshore borrow areas, where overfill factor calculations (R_a) indicate a 1:4.6 ratio. This means that for every cubic yard of beach to fill 4.63 yd^3 of material are required from target area I and 4.29 yd^3 of borrow material from target area II. Ocean View and Constance beaches have a much higher overfill ratio because of the coarser native beach material.

A.



B.

$$M_{\phi} = \frac{(\phi_{84}+\phi_{16})}{2}$$

$$R_J = e\left[\Delta\left(\frac{M_{\phi b}-M_{\phi n}}{\sigma_{\phi n}}\right) - \frac{\Delta^2}{2}\left(\frac{\sigma^2{}_{\phi b}}{\sigma^2{}_{\phi n}} - 1\right)\right]$$

ϕ_{84} = 84th percentile in phi units
ϕ_{16} = 16th percentile in phi units
σ represents the standard deviation where

Δ is a function of winnowing
b refers to borrow material
n refers to natural sand on beach
M is the phi mean diameter of the grain-size distribution.

$$\sigma_{\phi} = \frac{(\phi_{84}-\phi_{16})}{2}$$

Figure 11. A) Isolines of the adjusted overfill factor, R_a, for values of phi mean difference and phi sorting ratio. B) Formula for James replenishment factor, R_j (James 1975).

Table 3. Beach overfill characteristics for the replenishment of Ocean View to Holly Beach, Louisiana.

Beach	Mean (ϕ)	Sorting R_j	Target I R_a	Target II R_a
Holly Beach	2.93	.37	4.63	4.29
Highway 82	2.84	.37	5.37	4.74
Constance Beach	2.36	.40	21.61	9.02
Ocean View	2.48	.41	12.54	7.38

CONCLUSIONS

Coastal communities and resorts of Johnson's Bayou, Ocean View Beach, Constance Beach, Peveto Beach, Holly Beach, and Hackberry Beach are threatened by increasing beach erosion and storm impact vulnerability. Prior to 1954, shoreline retreat rates were relatively stable; however, since this time shoreline erosion rates have increased to between 2.1 and 3.9 m/yr. Study results using beach profile data collected between 1985 and 1988 show erosion rates at Holly Beach were roughly 1.2 m^3/m-yr.

Holly Beach to Ocean View Beach is composed of sand that is fine to very fine and derived from the reworking of Holocene deposits. In areas where mechanical grading occurs to maintain the beaches, grain size tends to be uniform and very well sorted. In areas where the beach has been left to natural processes, the sand tends to fine upward to the high-water line and coarsen in the area of dunes. Littoral transport along the chenier plain is between 62,000 and 100,000 yd^3 annually. Sediment supply in the Holly Beach and Constance Beach area is limited and very little if any of this material reaches the shoreline between Constance Beach and the Calcasieu River. However, there are several sand deposits offshore the chenier plain that are potential borrow sites for the replenishment of these eroding shorelines. Sediment from target area I channel-fill deposits ranges from 2.4 to 8.8 m thick, with 1.6 to 5.2 m of overburden of fine, unconsolidated clay and silt. Seismic interpretations show that these channels can reach over 18 m thick, and as much as 175,000,000 m^3 of sand and coarse silt are contained within the system. This sediment is inconsistent with characteristics of the native beach material. Therefore, the difference in textural characteristics of this material must be taken into account when calculating replenishment factors or overfill ratios for the beach front. Holly Beach has an overfill ratio of 1:4.63 for sands located in target area I and 1:4.29 from sands in target area II, meaning that for every cubic yard of beach to replenish, it would require 4.29 to 4.63 yd^3 of borrow material, depending on the site used in dredging.

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Appendix A

Mean Grain Size and Standard Deviation for Surficial Beach Sediment Samples

Grain-size Statistics for Surficial Samples

Sample	Mean	Standard Deviation
OV-1-D	2.3	.38
OV-1-H	2.7	.40
OV-1-M	2.4	.35
OV-1-L	2.3	.47
OV-2-D	2.3	.38
OV-2-H	2.7	.41
OV-2-M	2.6	.39
OV-2-L	2.5	.46
CB-1-H	2.5	.38
CB-1-M	2.2	.38
CB-1-L	2.3	.40
CB-2-M	2.4	.36
CB-2-L	2.4	.50
PB-1-H	2.6	.50
PB-1-M	2.4	.42
PB-2-H	2.6	.48
PB-2-M	2.6	.37
PB-3-H	2.8	.37
PB-3-M	2.7	.43
PB-4-D	2.8	.40
PB-4-H	2.8	.40
PB-4-M	2.7	.42
PB-5-D	2.7	.39
PB-5-H	3.0	.30
PB-5-M	3.1	.28
PB-5-L	3.2	.25
PB-6-D	2.5	.49
PB-6-H	3.1	.34
PB-6-M	3.0	.37
PB-6-L	3.1	.31
PB-7-D	2.7	.37
PB-7-H	3.1	.28
PB-7-M	2.9	.36
PB-7-L	3.1	.32
PB-8-D	2.4	.36
PB-8-H	3.0	.35
PB-8-M	3.1	.32
PB-8-L	3.1	.29

OV–Ocean View; CB–Constance Beach; PB–Peveto Beach; HB–Holly Beach
D–dune; H–high tide; M–mid tide; L–low tide

Grain-size Statistics for Surficial Samples cont'

SAMPLE	MEAN	STANDARD DEVIATION
HB-1-D	3.0	.28
HB-1-H	3.1	.28
HB-1-M	3.0	.33
HB-1-L	3.1	.33
HB-2-H	3.0	.32
HB-2-M	3.1	.30
HB-2-L	3.1	.30
HB-3-D	2.9	.31
HB-3-H	3.0	.31
HB-3-M	3.0	.34
HB-3-L	3.1	.37
HB-4-D	2.9	.30
HB-4-H	2.8	.33
HB-4-M	2.9	.34
HB-4-L	2.8	.45
HB-5-D	3.0	.29
HB-5-H	2.9	.34
HB-5-M	2.8	.43
HB-5-L	2.9	.55
HB-6-D	2.8	.36
HB-6-H	3.0	.35
HB-6-M	2.9	.43
HB-6-L	3.0	.49
HB-7-D	2.8	.34
HB-7-H	2.9	.38
HB-7-M	3.0	.36
HB-7-L	2.9	.35
HB-8-D	2.7	.40
HB-8-M	2.8	.49
HB-8-L	2.7	.54
HB-9-H	2.8	.34

Appendix B

Sediment Size Characterisics from Offshore Core Samples

SUMMARY OF GRAIN SIZE STATISTICS: MOMENT MEASURES

NOTE: Mean grain size is reported in phi units with millimeter values in parentheses. Abbreviations in parentheses in the standard deviation column refer to very well sorted (VWS), well sorted (WS), moderately well sorted (MWS), moderately sorted (MS), poorly sorted (PS), very poorly sorted (VPS), and extremely poorly sorted (EPS).

SAMPLE NUMBER	MEAN ϕ	STANDARD DEVIATION	SKEWNESS
PB-1-0-3-1	7.69	2.68(VPS)	1.69
PB-1-0-3-2	3.81	1.21(PS)	3.58
PB-1-0-3-3	4.55	1.34(PS)	1.26
PB-1-0-5-1	4.17	1.92(PS)	1.06
PB-1-0-5-2	3.07	0.78(MS)	1.29
PB-1-0-5-3	3.42	1.22(PS)	0.31
PB-1-0-5-4	4.04	1.92(PS)	0.54
PB-1-0-6-1	4.46	1.28(PS)	1.51
PB-1-O-6-2	2.92	1.10(PS)	0.94
PB-1-O-6-3	4.66	1.84(PS)	0.61
PB-1-1	3.62	1.39(PS)	0.75
PB-1-2	6.94	2.36(VPS)	2.10
PB-2-1	3.80	1.31(PS)	0.76
PB-2-2	3.11	0.62(MWS)	1.98
PB-2-3	3.31	1.22(PS)	2.94
PB-3-1	4.6	1.02(PS)	-3.22
PB-3-2	4.92	0.55(MWS)	-1.30
PB-3-3	5.00	0.49(WS)	-1.12
PB-3-4	5.00	0.40(WS)	-3.33
PB-3-5	2.84	0.73(MS)	2.12
PB-3-6	2.43	0.84(MS)	1.73
PB-4-1	4.04	1.68(PS)	-1.40
PB-4-2	3.52	1.62(PS)	1.69
PB-4-3	3.51	1.41(PS)	-0.02
PB-4-4	3.81	0.97(MS)	0.63
PB-4-5	7.53	1.59(PS)	-1.39
PB-5-1	3.16	1.66(PS)	-0.37
PB-5-2	1.79	1.82(PS)	0.26
PB-5-3	3.79	1.20(PS)	0.46
PB-5-4	4.08	1.25(PS)	1.64
PB-5-5	3.92	1.26(PS)	1.57
PB-5-6	4.15	1.01(PS)	0.34
PB-5-7	6.84	2.27(VPS)	1.8
PB-7-1	4.60	0.95(MS)	-0.04
PB-7-2	4.77	0.90(MS)	-0.13
PB-7-3	4.69	0.91(MS)	0.06
PB-7-4	4.37	0.89(MS)	0.60
PB-7-5	4.81	0.83(MS)	-0.34
PB-7-7	4.87	0.77(MS)	-0.39
PB-7-8	4.19	1.26(PS)	-2.37
PB-7-9	4.31	0.87(MS)	0.22

SAMPLE NUMBER	MEAN ϕ	STANDARD DEVIATION	SKEWNESS
PB-7-10	4.10	0.89(MS)	-0.03
PB-7-11	4.60	1.00(MS)	-3.17
PB-8-1	3.64	1.73(PS)	2.23
PB-8-2	6.15	2.04(VPS)	1.20
PB-9-1	4.00	1.69(PS)	1.76
PB-9-2	3.86	1.39(PS)	1.75
PB-9-3	3.70	1.34(PS)	1.93
PB-9-4	4.46	1.61(PS)	1.53
PB-9-5	6.81	2.23(VPS)	-0.75
PB-10-1	7.14	2.51(VPS)	1.90
PB-10-2	3.03	1.29(PS)	-0.44
PB-10-3	4.13	1.39(PS)	2.64
PB-10-4	3.02	0.83(MS)	1.18
PB-10-5	3.91	1.13(PS)	0.41
PB-10-6	3.42	2.02(VPS)	-0.37
PB-10-7	3.58	1.12(PS)	0.16
PB-11-1	3.57	1.49(PS)	1.62
PB-11-2	3.18	1.12(PS)	1.94
PB-11-3	4.32	1.55(PS)	1.28
PB-11-5	3.95	1.42(PS)	1.31
PB-11-6	6.68	2.24(VPS)	-0.64
PB-12-1	3.81	1.36(PS)	-1.84
PB-12-2	4.23	0.88(MS)	-0.22
PB-12-3	3.72	1.50(PS)	-1.90
PB-12-4	2.03	0.71(MWS)	1.21
PB-12-5	4.24	1.22(PS)	-1.05
PB-12-6	2.58	0.69(MWS)	1.58
PB-12-7	2.99	0.94(MS)	0.97
PB-12-8	3.93	1.28(PS)	-1.00
PB-12-9	6.95	1.64(PS)	-0.93
PB-13-1	3.92	1.65(PS)	1.14
PB-13-2	4.26	1.64(PS)	3.00
PB-13-3	4.13	1.30(PS)	1.86
PB-13-4	6.58	2.42(VPS)	-0.56
PB-14-1	4.68	1.23(PS)	-0.58
PB-14-2	3.98	1.51(PS)	1.62
PB-14-3	4.57	1.42(PS)	1.01
PB-14-4	4.16	1.36(PS)	1.23
PB-15-1	4.56	1.47(PS)	1.27
PB-15-2	5.07	1.42(PS)	0.83
PB-15-3	4.35	1.41(PS)	0.45
PB-15-4	3.98	1.72(PS)	0.16
PB-15-5	7.22	2.45(VPS)	1.90
PB-16-G-1	4.22	0.98(MS)	-0.39
PB-16-G-2	3.70	0.95(MS)	0.95
PB-16-G-3	4.41	0.87(MS)	-0.20

SAMPLE NUMBER	MEAN ϕ	STANDARD DEVIATION	SKEWNESS
PB-16-G-4	3.80	1.09(PS)	0.09
PB-16-G-6	5.82	1.02(PS)	1.44
PB-17-1	3.75	1.30(PS)	2.28
PB-17-2	4.56	1.30(PS)	1.03
PB-17-4	3.75	1.31(PS)	-0.06
PB-17-5	3.76	1.10(PS)	0.65
PB-17-6	4.01	1.13(PS)	0.94
PB-17-7	3.67	1.09(PS)	0.81
PB-17-8	3.48	1.45(PS)	-0.26
PB-17-9	3.67	1.09(PS)	0.34
PB-17-10	3.42	1.17(PS)	0.48
PB-17-11	3.94	1.10(PS)	0.97
PB-17-12	6.31	2.22(VPS)	-0.31
PB-18-1	3.82	1.23(PS)	0.78
PB-18-2	3.98	1.27(PS)	0.53
PB-18-3	3.23	1.08(PS)	1.39
PB-18-4	4.04	1.21(PS)	0.54
PB-18-5	4.36	1.09(PS)	0.42
PB-18-6	4.02	0.91(MS)	0.57
PB-18-7	4.15	1.20(PS)	0.63
PB-18-8	4.57	0.96(MS)	0.75
PB-18-9	5.10	1.38(PS)	0.76
PB-18-10	4.32	1.97(PS)	1.27
PB-18-11	5.05	1.75(PS)	0.51
PB-19-1	4.36	1.29(PS)	0.77
PB-19-2	4.51	1.41(PS)	0.82
PB-19-3	4.88	1.36(PS)	1.01
PB-19-4	4.87	1.37(PS)	1.06
PB-19-5	6.31	1.42(PS)	0.98
PB-19-6	4.66	2.16(VPS)	-0.21
PB-20-G-3	4.15	1.07(PS)	0.41
PB-20-G-5	3.92	1.02(PS)	0.54
PB-20-G-7	4.26	0.99(MS)	0.65
PB-20-G-10	4.68	0.85(MS)	-0.51
PB-20-G-12	4.71	0.77(MS)	-2.90
PB-20-RI-G-1	2.98	0.49(WS)	2.90
PB-20-RI-G-2	3.30	0.87(MS)	1.58
PB-20-RI-G-4	4.01	0.97(MS)	0.45
PB-20-RI-G-6	4.59	1.00(MS)	0.10
PB-20-RI-G-9	3.92	0.90(MS)	1.15
PB-20-RI-G-11	4.22	1.49(PS)	-2.04
PB-21-G-1	3.30	0.61(MWS)	2.61
PB-21-G-2	3.30	0.78(MS)	2.00
PB-21-G-3	3.54	0.77(MS)	1.97
PB-21-G-4	3.45	0.82(MS)	1.73
PB-21-G-5	3.60	0.84(MS)	1.51
PB-21-G-6	4.57	0.93(MS)	-0.15
PB-21-G-7	3.66	0.92(MS)	1.15

SAMPLE NUMBER	MEAN ϕ	STANDARD DEVIATION	SKEWNESS
PB-21-G-8	4.17	1.02(PS)	0.30
PB-21-G-9	4.79	0.74(MS)	-0.75
PB-21-G-10	5.92	1.46(PS)	0.93
PB-22-G-1	2.59	0.55(MWS)	3.27
PB-22-G-2	3.06	0.83(MS)	1.67
PB-22-G-3	2.89	0.44(WS)	2.83
PB-22-G-4	3.04	0.66(MWS)	1.98
PB-22-G-5	2.56	0.69(MWS)	2.60
PB-22-G-6	3.72	0.94(MS)	0.58
PB-22-G-7	4.46	1.20(PS)	-2.27
PB-23-G-1	2.79	0.71(MWS)	2.40
PB-23-G-2	2.94	0.62(MWS)	2.22
PB-23-G-3	3.03	0.59(MWS)	2.27
PB-23-G-4	3.01	0.65(MWS)	1.89
PB-23-G-5	2.98	0.56(MWS)	2.25
PB-23-G-6	3.04	0.55(MWS)	2.38
PB-23-G-7	4.58	0.79(MS)	-0.50
PB-23-G-8	4.19	0.98(MS)	0.22
PB-23-G-9	3.71	1.02(PS)	1.05
PB-23-G-10	4.73	0.77(MS)	-0.72
PB-23-G-11	4.56	0.96(MS)	-0.13
PB-24-G-1	3.95	1.07(PS)	0.64
PB-24-G-2	4.67	0.88(MS)	-0.48
PB-24-G-3	4.98	0.49(WS)	-2.00
PB-24-G-4	4.58	0.53(MWS)	-1.76
PB-24-G-5	4.69	0.60(MWS)	-1.72
PB-24-G-6	3.94	1.47(PS)	-1.43
PB-25-1	3.35	1.39(PS)	0.19
PB-25-2	3.28	1.81(PS)	0.95
PB-25-3	3.52	1.50(PS)	0.82
PB-25-5	3.33	1.16(PS)	0.91
PB-25-6	4.24	1.87(PS)	0.95
PB-26-G-1	2.63	0.71(MWS)	2.07
PB-26-G-2	4.62	0.86(MS)	-1.99
PB-26-G-3	3.88	1.12(PS)	0.71
PB-26-G-4	4.31	0.98(MS)	-0.49
PB-26-G-5	4.41	0.85(MS)	-0.55
PB-26-G-6	4.65	0.83(MS)	-1.15
PB-27-G-1	4.07	1.04(PS)	0.19
PB-27-G-2	3.56	0.93(MS)	1.29
PB-27-G-3	4.12	1.03(PS)	-0.06
PB-27-G-4	3.64	1.46(PS)	-1.39
PB-27-G-5	4.58	1.21(PS)	-1.42
PB-28-1	4.02	1.38(PS)	0.96
PB-28-2	4.05	1.35(PS)	0.87

SAMPLE NUMBER	MEAN ϕ	STANDARD DEVIATION	SKEWNESS
PB-28-3	6.13	2.36(VPS)	-0.94
PB-28-4	3.63	1.42(PS)	0.16
PB-29-1	3.62	1.49(PS)	0.32
PB-29-2	4.31	1.57(PS)	0.56
PB-29-3	4.01	1.90(PS)	-0.23
PB-30-1	4.06	1.25(PS)	1.44
PB-30-2	4.50	1.52(PS)	1.09
PB-30-3	4.21	1.43(PS)	1.67
PB-30-4	3.99	2.10(VPS)	0.22